

## METHOD AND APPARATUS FOR LOADING CATALYST

### **BACKGROUND OF THE INVENTION**

#### **Field of the Invention**

[0001] Embodiments of the present invention generally relate to methods and apparatus for filling particulate material into a tube. More particularly embodiments of the present invention generally relate to methods and apparatus for filling a catalyst into a tube of a primary reformer furnace.

#### **Description of the Related Art**

[0002] Primary reformer furnaces such as those used in the production of ammonia, hydrogen and methanol typically utilize tens or hundreds of heat transfer tubes that are filled with catalyst particles. These tubes must initially be filled with catalyst, and used catalyst must be replaced with fresh catalyst periodically. Voids in the catalyst fill can easily form if catalyst particles are introduced to the tubes too quickly or non-uniformly during the filling of the tubes. Also, catalyst particles can fracture or crush if they are allowed to free-fall too far during filling of the tubes. Voids or crushed catalyst create local density variations as well as a catalyst density that is less than optimal. Local density variations differ from tube to tube and cause variations in the pressure drop over the tubes. This results in distortions of gas distribution in a multi-tube reactor and causes uneven temperature distribution over the tubes during operation of the reactor. The resultant thermal and mechanical stress in the tube can reduce its useful life. To reduce voids the tube can be vibrated by such methods as tapping or vibrating the upper part of the tube. However, this is laborious and delays the filling operation. Additionally, tapping or vibration can expose the tube to extra mechanical stress. If excessive crushing or fracturing of catalyst particles occurs during filling, the only remedy is to remove all catalyst from the tube and refill it properly. This adds substantial labor and results in the loss of expensive catalyst

[0003] One method for reducing density variations utilizes a short sock or sock-like member made of a material such as a soft plastic that is first filled with the catalyst. The catalyst can be delivered from the manufacturer already in the socks. When filling the tubes, a sock filled with catalyst is fastened onto a line and lowered towards the bottom of each tube. By jerking the line, the sock opens at its bottom and the catalyst

flows into the tube with a minimum of free fall. However, there are several disadvantages with this method. Filling one tube with this method usually requires a number of the socks thereby making the method laborious. Sometimes, the sock will open prematurely, allowing the catalyst particles to fall a great distance and achieve enough gravimetrically induced velocity to crush or fracture when they hit the bottom of a tube. If the sock contains voids among the particles of catalyst, then corresponding voids will typically form in the tube when the sock is emptied. Consequently, the tubes must be exposed to tapping or vibrating to secure reasonably even gas distribution over the tubes.

10 [0004] Another method for attaining good and even packing of catalyst into a tube includes filling the tube with water and then pouring in the catalyst. However, this method requires that the water subsequently be completely removed. Removal of the water and necessary subsequent drying takes a long time. Additionally, used water requires special treatment, adding time and cost.

15 [0005] RD Patent Application RD-253040-A describes a method for filling a tube with a catalyst by adding the catalyst to the upper part of the tube by means of a transporter comprising a slowly rotating arrangement. The catalyst is transported from a container through a duct in which there is a rod with oblique/transverse propeller wings or brushes. The catalyst particles are then transported to the upper end of the catalyst tube and fall smoothly into the tube. However, the particles must be added slowly in order to get even filling of the tube. Further, the catalyst drops a significant length especially during the first part of the filling operation thereby permitting the catalyst to be crushed or broken during the fall. Therefore, the particles can pack unevenly over the vertical length of the tube and the filling time can be long.

25 [0006] Therefore, there exists a need for a catalyst loading tool that is cost effective to manufacture and is easily configurable to accommodate particular loading requirements for a given reactor. There exists a further need for a catalyst loading tool that permits filling of reactor tubes evenly without breaking the catalyst particles.

### **SUMMARY OF THE INVENTION**

30 [0007] Embodiments of the present invention generally relate to methods and apparatus that prevent breakage of a catalyst particle and evenly fill the catalyst into

tubes to an optimum density. Particles of catalyst can empty directly down into the tubes in order to obtain quick filling of the tubes. However, a loading tool softens the fall of the catalyst and provides even filling of the tube in order to avoid crushing or breaking of the catalyst and the formation of catalyst voids in the tube. The loading tool  
5 comprises a center member, such as a rod, a wire, a chain, or the like with a plurality of damper members shaped in different ways but each having a radial extension smaller than the inner radius of the tube. In operation, the center member can be jerked during the filling operation while simultaneously being lifted up gradually as the tube fills. Alternatively, the center member can remain stationary with its lowest extremity slightly  
10 above the anticipated fill level of the catalyst being added. In either type of operation, limited, pre-determined amounts of catalyst are introduced sequentially to allow periodic adjustment of the position of the lowest extremity of the center member. The damper members reduce the falling velocity of the catalyst and divert the catalyst from falling in straight downward paths. This avoids bridge formation of the catalyst particles  
15 during filling. The type and shape of the damper member and center member can be adapted in particular cases to the actual type of catalyst particles and the tube diameter. The damper members can be stiff or flexible since they do not occupy a substantial portion of the cross section of the tube at any particular axial location. The height of the lowest extremity of the center member can be periodically adjusted  
20 manually by physically feeling the center member change from tension to slackness as the lowest extremity of the center member contacts the catalyst interface. In another embodiment of the present invention, a sensor member can be positioned at a lower portion of the center member to communicate with the top of the center member to provide visual or auditory indication of contact with the catalyst interface.

25

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0008] So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which  
30 are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to

be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0009] Figure 1 is a schematic view showing a tube filled in a conventional manner.

[0010] Figure 2 is a schematic view showing a tube filled in accordance with an  
5 embodiment of the invention.

[0011] Figure 3 is a view of a damper member attached to a center member in  
- accordance with an embodiment of the invention.

### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

10 [0012] Figure 1 shows a tube 10 such as a catalyst tube of a reactor. As illustrated, filling the tube 10 by allowing the particles 12 to fall directly down the tube produces voids 14 and broken particles 16.

[0013] Figure 2 shows particles 12 such as catalyst falling into a tube 10 that includes a loading tool 20. The loading tool 20 comprises a center member 22 such as  
15 a wire, a chain, a rod, or the like and a plurality of damper members 24 substantially transverse and axially arranged on the center member 22 to provide substantially circumferential coverage along a longitudinal length of the tube 10. The center member 22 can be stiff or flexible. The distance between damper members 24 on the center member 22 can be substantially equal or can vary. The plurality of damper members  
20 24 reduces the falling velocity of the particles 12 and diverts the particles from falling in straight downward paths. Since the damper members 24 do not occupy a substantial portion of the cross section of the tube 10 at any particular axial location they can be stiff or flexible and still permit the particles 12 to fall. The loading tool 20 can be moved or jerked primarily in both directions axially and is pulled gradually out of the tube 10 as  
25 the tube is filled, or it can remain stationary while catalyst is being added and then pulled upwards in the tube between catalyst filling sequences. As the loading tool 20 is removed from the tube 10, it can be broken into sections at a coupling 28 such as an eyelet and mating shackle that can be positioned within the center member 22. Therefore, the amount of the loading tool 20 that has to be handled outside of the tube  
30 10 is limited to the length between couplings 28 on the center member 22. The



particles 12 can pour down into the tube 10 through a funnel 26 that is removed after filling is completed. However, the particles 12 can be added to the tube through other methods known in the art.

5 [0014] Figure 3 illustrates an embodiment for the damper member 24. As shown, the damper member 24 is an inexpensive and easily adjustable commercially available fastener having a locking portion 30 that attaches a longitudinal member 32 around the center member 22 of the loading tool 20. Additionally, the longitudinal member 32 can pass back through a portion of the locking portion 30 in order to form a loop on one side thereof. The locking portion 30 and longitudinal member 32 of the damper member 24  
10 can be made of a metal or plastic with varying degrees of stiffness. Shaping of the damper member 24 and changes to length, stiffness, number, axial spacing on the center member 22, etc., can be adapted to the material to be filled into the tube 10 and the size of the tube 10. These changes can be accomplished since the damper member 24 is cheap and can be adjusted easily.

15 [0015] Periodic adjustments of the height of the lowest extremity of the center member can be made manually. This is accomplished by physically feeling the center member change from tension to slackness as the lowest extremity of the center member contacts the catalyst interface, similar to the sensation from a weighted fishing line contacting the bottom of a body of water. In one embodiment of the present invention,  
20 periodic adjustments also can be assisted by the addition of a sensor member at the lowest extremity of the center member. This sensor member can communicate with the top of the center member to provide visual or auditory indication of contact with the catalyst interface.

[0016] With embodiments of the present invention, a novel, reproducible, and quick  
25 filling method is disclosed. The method is gentle to the particles such that crushing of particles during the filling operation is avoided. An even filling of the tube is also obtained, and thus one result has been avoidance of uneven temperature distribution when a tube filled with catalyst is in operation. Further, an even density of particles in the tubes is attained without exposing them to tapping/vibration, which is both time-  
30 consuming and damaging to the tubes. Consequently, time is saved both during filling and also since the tubes do not have to be tapped. The method is simple, cost efficient, and can be modified both quickly and easily. Additionally, it is to only a very

small degree dependent upon whoever is the particular operator during the filling process. Furthermore, errors connected with filling of particles into socks are avoided. A substantial degree of freedom regarding packaging and the form of transport for the particles also is obtained.

- 5 [0017] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.